

**OVERVIEW OF BERYLLIUM
EXPOSURE CONTROL AND ITS
EXPOSURE ASSESSMENT :
AN UPDATE**

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PLANT PROCESS

BERYL ORE



SODIUM BERYLLIUM FLUORIDE



BERYLLIUM HYDROXIDE



AMMONIUM BERYLLIUM FLUORIDE



BERYLLIUM FLUORIDE



BERYLLIUM INGOT



POWDER PRODUCTION



BERYLLIUM VHP BLOCKS



MACHINING





CONTROL MEASURES

➤ ENGINEERING

- **Plant layout**
- **Ventilation**
- **Air cleaning system**
- **Negative pressure**

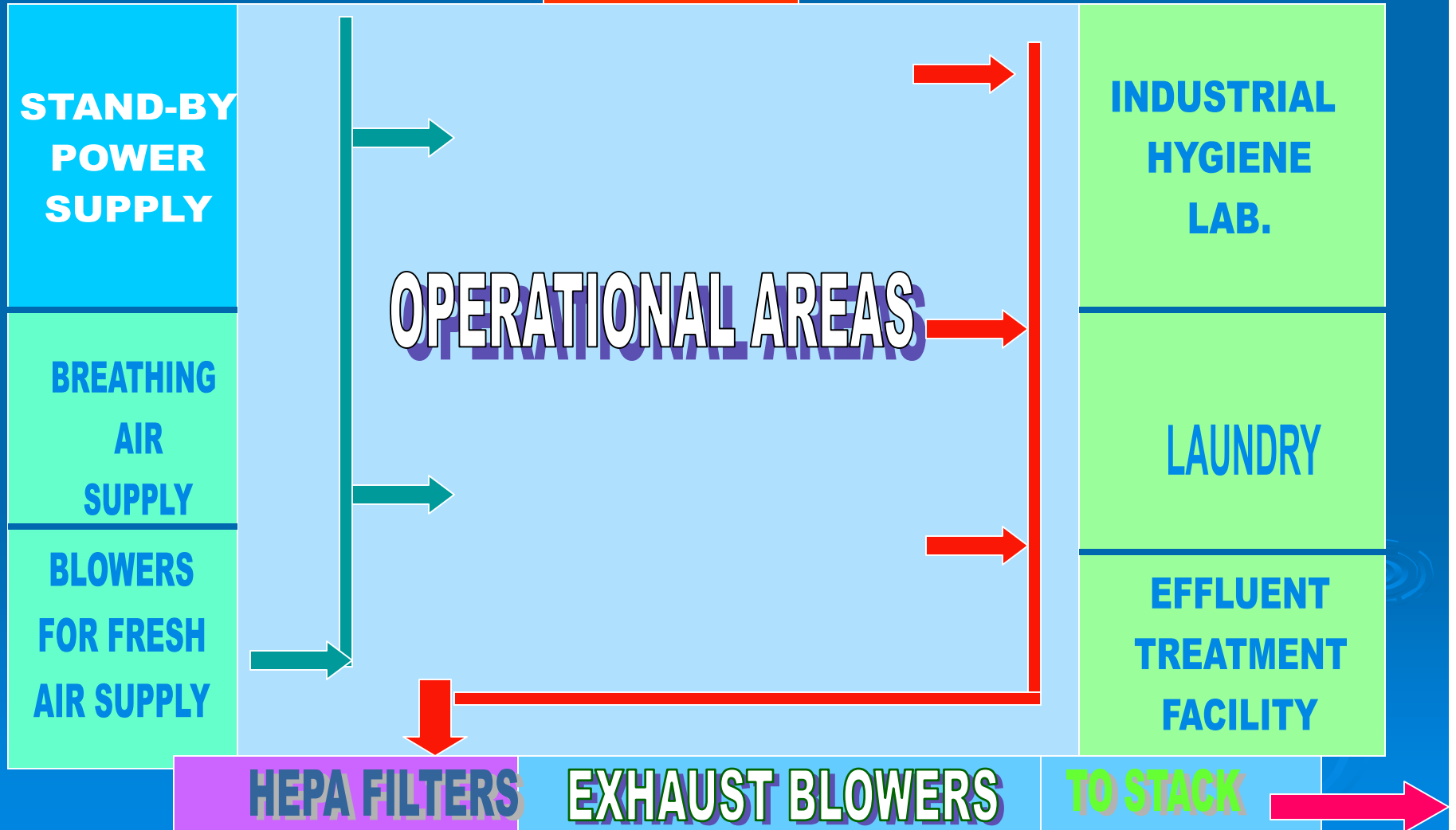
➤ PERSONAL

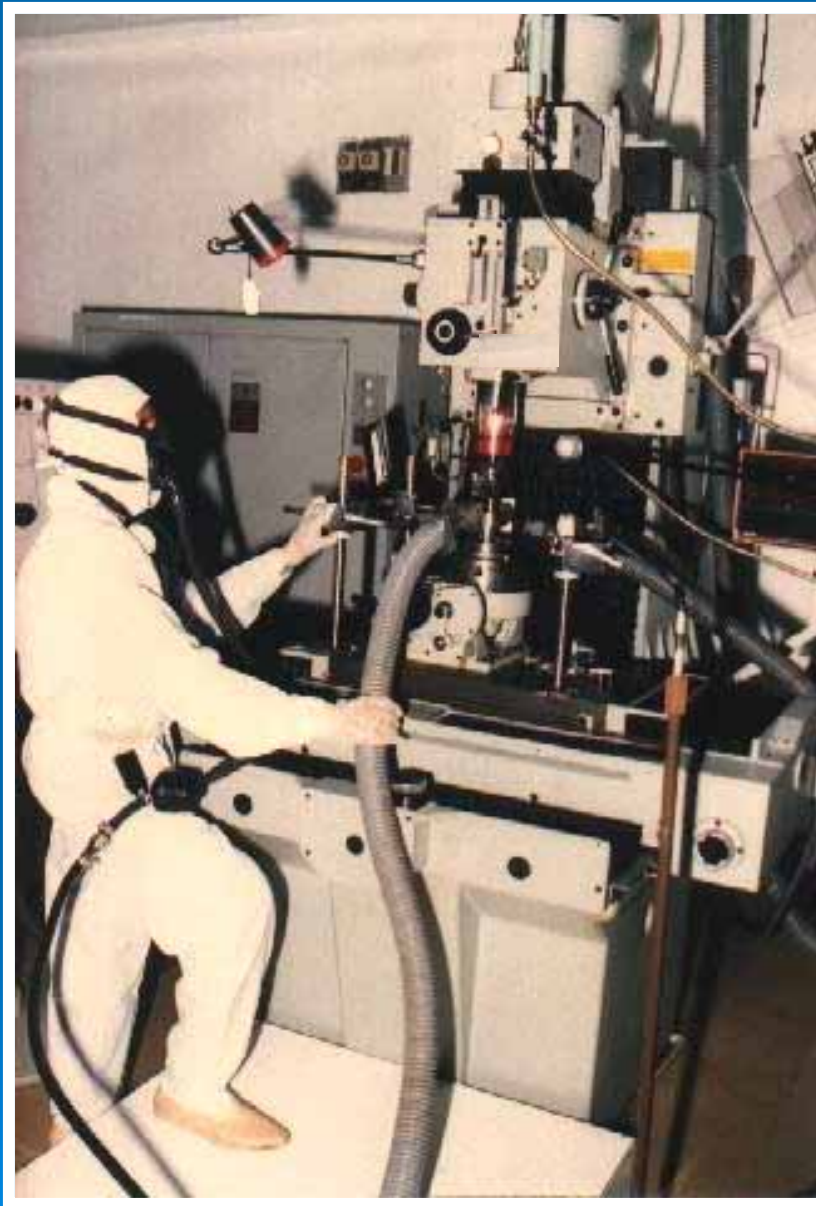
- **Personal Protective Equipments**
- **Change Rooms & Showers**

PLANT LAYOUT

CHANGE ROOMS

BARRIER







CONTROL MEASURES (contd.)

➤ ADMINISTRATIVE

- Air monitoring
- Operational safety procedures
- Training

➤ MEDICAL

- Pre-employment
- Annual
- Be-LPT screening

COMMITTEES FOR OPERATIONAL SAFETY

APEX SAFETY COMMITTEE

UNIT LEVEL SAFETY COMMITTEE

LOCAL SAFETY COMMITTEE



PERMISSIBLE LIMITS

| Medium | | Description | Limits |
|---------|-----------------------------------|--|---|
| Air | Work Place Emission Ambient | TLV Release at 30 meters 30-days average | 2.0 $\mu\text{g}/\text{m}^3$ 0.3 $\mu\text{g}/\text{m}^3$ 0.01 $\mu\text{g}/\text{m}^3$ |
| Surface | - | Equipment and floor | 10.0 ng/cm^2 |
| Waste | Liquid effluent Solid | | 0.1 $\mu\text{g}/\text{ml}$ 0.1 $\mu\text{g}/\text{g}$ |

CHEMICAL ANALYSIS

➤ SAMPLE PREPARATION

➤ QUANTIFICATION TECHNIQUES

| TECHNIQUE | WORKING RANGE | DETECTION LIMITS | INTERFERENCE | SAMPLE MATRICES |
|-------------|----------------|------------------|--------------|-----------------------------------|
| FLUOROMETRY | 10 – 200 ng/ml | 0.5 ng/ml | Fe, Al, Ca | Occupational air, swipe, effluent |
| GFAAS | 0.5 - 5 ng/ml | 0.10 ng/ml | Salts, Ca | Ambient air, urine, water, soil |

➤ STANDARD QA/QC PROTOCOL

BERYLLIUM EXPOSURE ASSESSMENT

➤ INHALATION EXPOSURE MONITORING

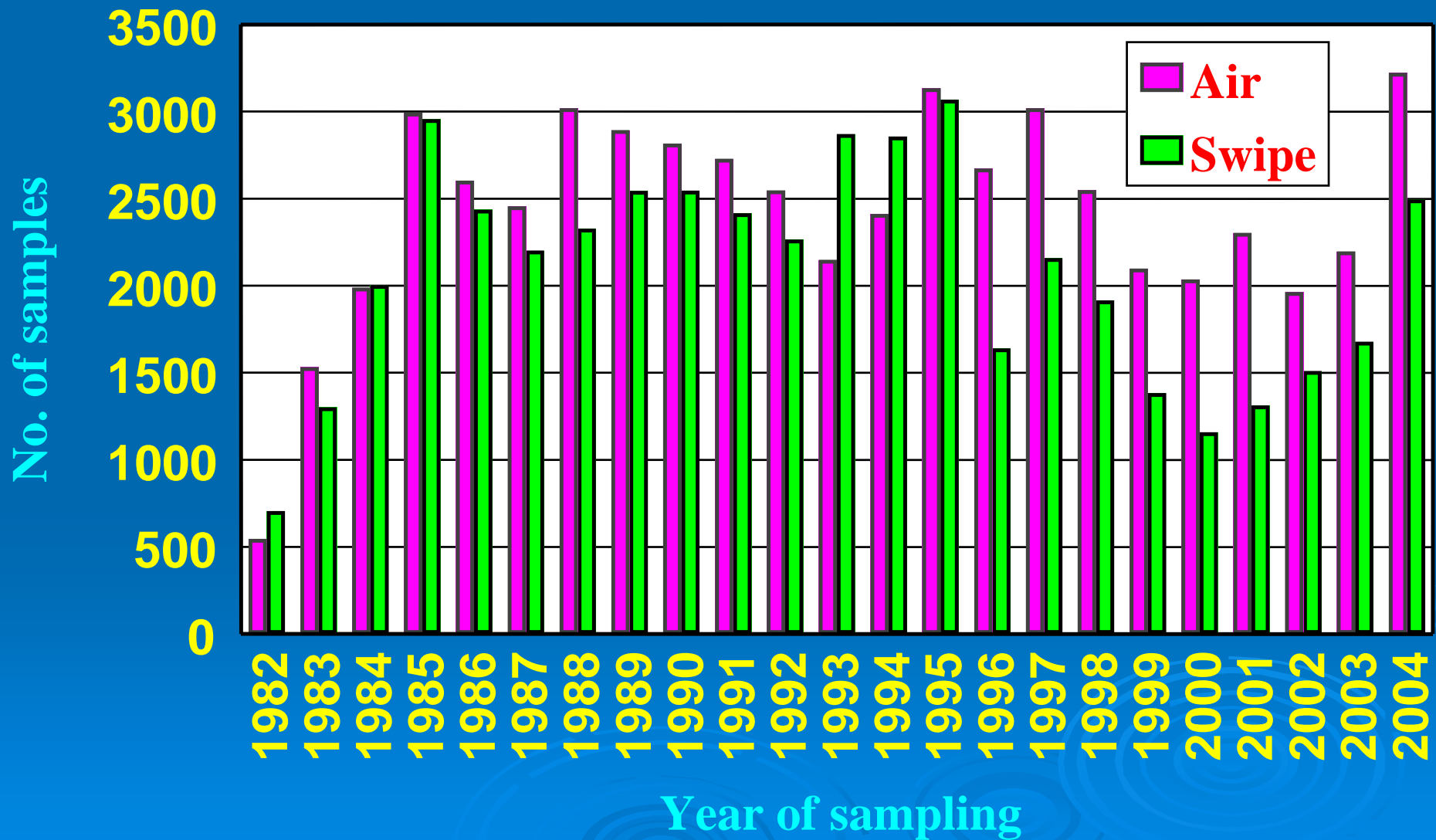
- AREA SAMPLING
- BREATHING ZONE SAMPLING
- STACK MONITORING

➤ SURFACE MONITORING

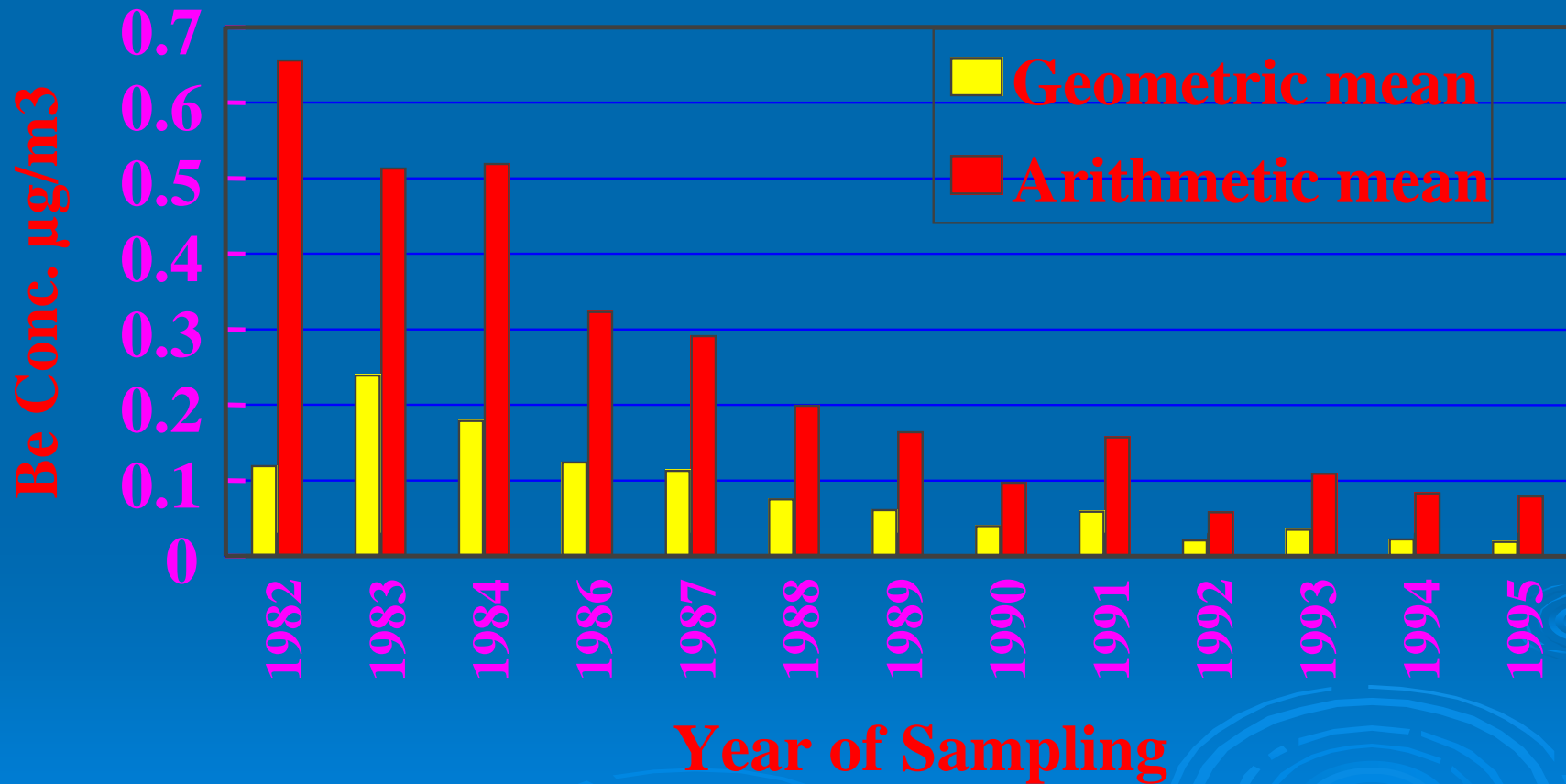
- SWIPE AND IN-PLANT SETTLED DUST SAMPLING
- LAUNDRY IN-PLANT GARMENT SAMPLING



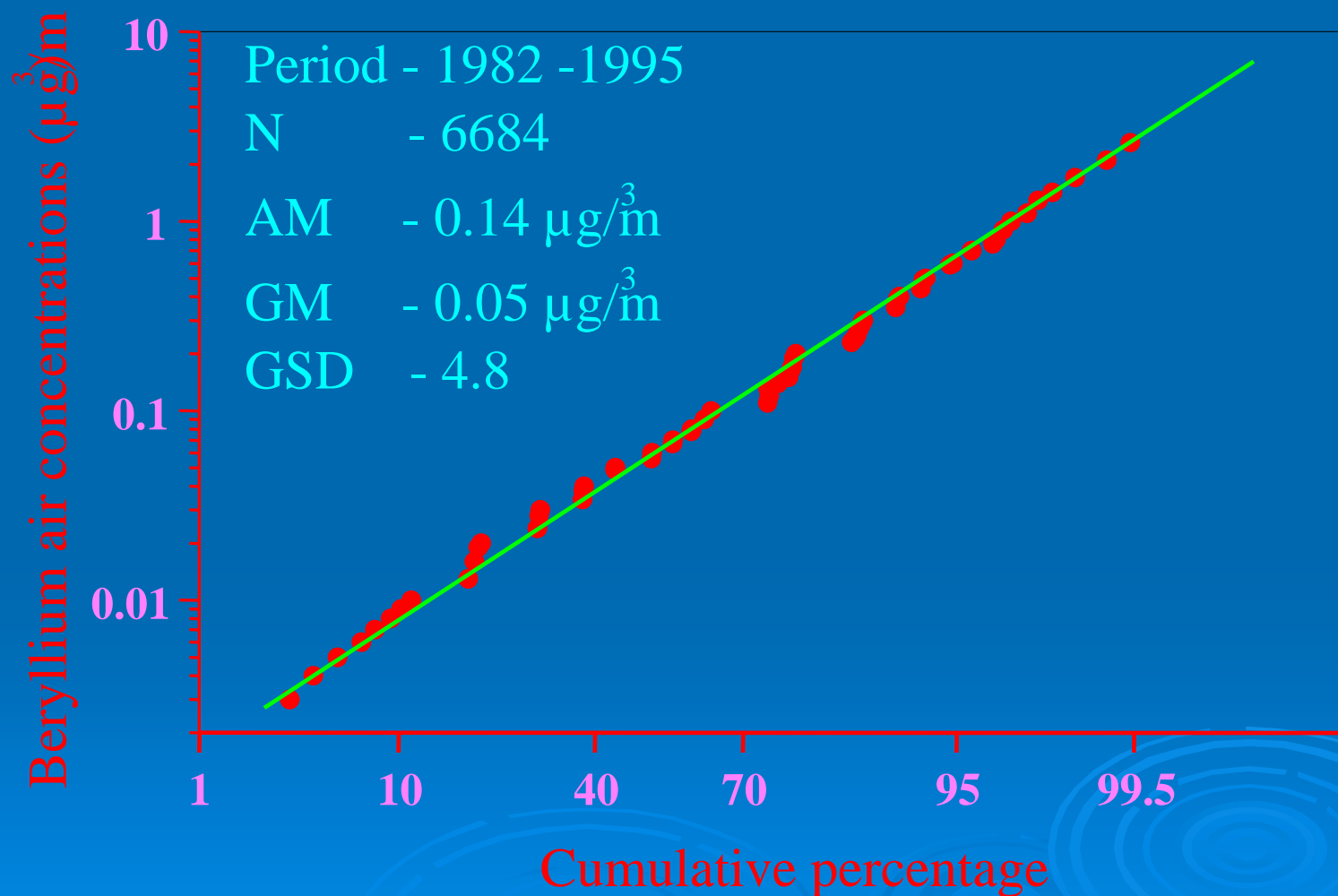
STATISTICS OF OCCUPATIONAL AIR AND SWIPE SAMPLES



Average air concentrations of beryllium in occupational environment



CUMULATIVE FREQUENCY DISTRIBUTION (%) OF BERYLLIUM CONCENTRATIONS IN OCCUPATIONAL AIR

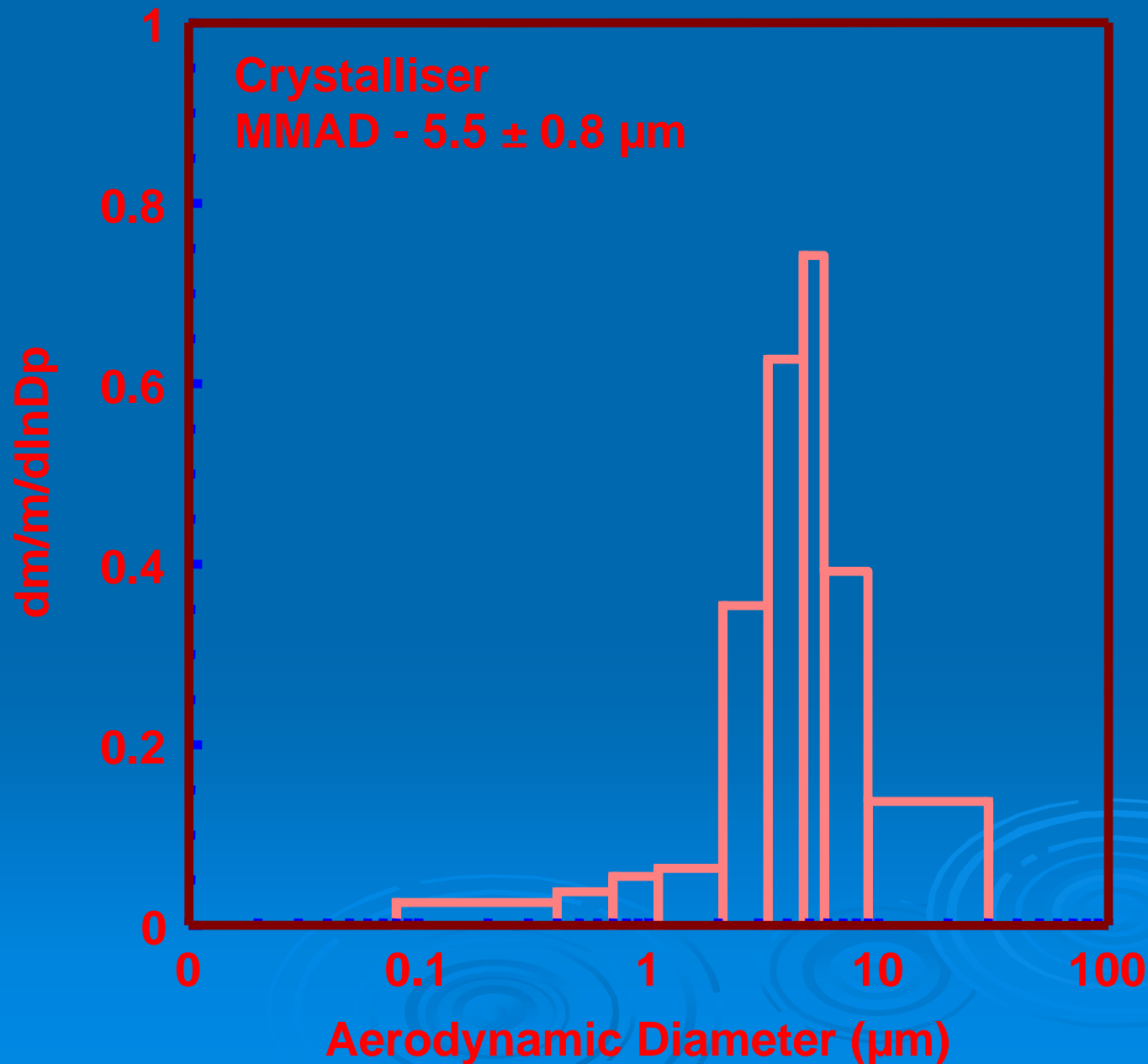


PHYSICOCHEMICAL CHARACTERISATION

- PARTICLE SIZE DISTRIBUTION
- RESPIRATORY DEPOSITION ESTIMATION
- SOLUBILITY STUDIES



PARTICLE SIZE DISTRIBUTION OF BERYLLIUM



MASS MEDIAN AERODYNAMIC DIAMETERS (μm) IN VARIOUS PROCESSING AREAS

| AREA | MMAD | GSD |
|----------------------------|------|-----|
| ORE MIXING | 5.7 | 2.4 |
| CRUSHING | 6.4 | 1.7 |
| LEACHING | 5.0 | 2.1 |
| Be(OH) ₂ FILTER | 8.8 | 1.9 |
| DISSOLUTION | 6.0 | 2.0 |
| CRYSTALLISER | 5.2 | 2.1 |
| DRYER | 7.0 | 1.9 |
| FURNACE | 9.7 | 1.7 |
| POWDER PROD. | 6.3 | 2.4 |
| MACHINING | 7.9 | 1.9 |

ESTIMATED ALVEOLAR DEPOSITION (ICRP MODEL)

| SAMPLING AREA | ALVEOLAR DEPOSITION | |
|----------------------------|---------------------|------|
| | Nasal | Oral |
| ORE MIXING | 0.05 | 0.12 |
| CRUSHING | 0.05 | 0.11 |
| LEACHING | 0.05 | 0.13 |
| Be(OH) ₂ FILTER | 0.03 | 0.09 |
| DISSOLUTION | 0.04 | 0.11 |
| CRYSTALLISER | 0.05 | 0.13 |
| DRYER | 0.04 | 0.10 |
| FURNACE | 0.04 | 0.10 |
| POWDER PROD. | 0.04 | 0.11 |
| MACHINING | 0.04 | 0.11 |

PROCESS BASED EXPOSURES

| OPERATIONS | COMPOUNDS HANDLED | POSSIBLE FORMS OF EXPOSURES |
|---|--|-----------------------------|
| MIXING, SINTERING, CRUSHING & LEACHING | Beryl ore, Na_2SiF_6 | Particulate |
| $\text{Be}(\text{OH})_2$, ABF, PRODUCTION | Na_2BeF_4 , $(\text{NH}_4)_2\text{BeF}_4$, HF | Particulate & HF fumes |
| DECOMP., REDUCTION | $(\text{NH}_4)_2\text{BeF}_4$, Mg, BeF_2 , NH_4F_2 | Particulate & fumes |
| POWDER PROD., MACHINING | Be Metal | Particulate |

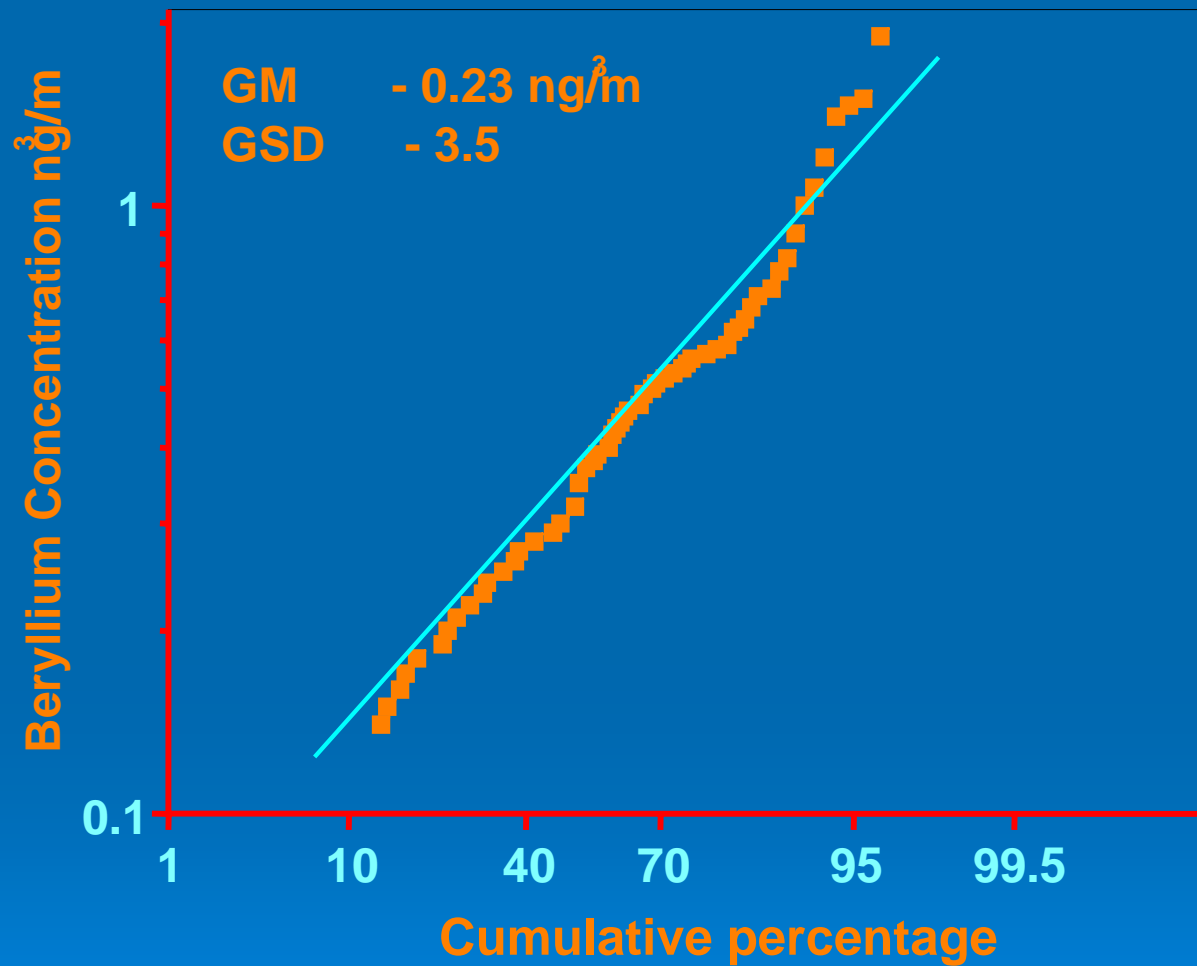
DISSOLUTION KINETICS IN SIMULATED LUNG FLUID

| COMPOUND | PARTICLE SIZE μm | % DISSOLVED IN 23 DAYS |
|------------------|--------------------------------|---------------------------|
| Be POWDER | 1.2 | 0.007 |
| Be POWDER | 8.7 | 0.005 |
| Beryllium Oxide | 2.3 | 0.003 |
| BERYL ORE | 2.7 | 0.009 |
| RED MUD | BULK SAMPLE | 7.6 |
| AEROSOL (SPM) | COMPOSITE | 0.28 |

AMBIENT AIR CONCENTRATIONS (PERIOD - 1991-2004)

| Sampling Site | No. of Samples | Beryllium Concentration in ng/m ³ | | |
|--------------------------|--|--|-------------|------------|
| | | Range | Arith. mean | Geom. mean |
| Site – 1 | 76 | 0.01 – 1.22 | 0.24 ± 0.22 | 0.12(4.5) |
| Site – 2 | 151 | 0.01 – 1.92 | 0.37 ± 0.31 | 0.24 (3.3) |
| Site – 3 | 149 | 0.08 – 2.50 | 0.56 ± 0.46 | 0.43 (2.0) |
| Site – 4 | 44 | 0.01 – 2.10 | 0.52 ± 0.41 | 0.44 (2.5) |
| Site – 5 | 32 | 0.06 – 0.63 | 0.28 ± 0.16 | 0.23 (1.9) |
| Literature values | <i>Urban air (USA) - <0.1 to 6.7 ng/m³</i> <i>Japanese cities - max. 0.2 ng/m³</i> | | | |

BERYLLIUM CONC. IN AMBIENT AIR



BERYLLIUM ENRICHMENT FACTOR IN AMBIENT AIR

$$EF (x)_{\text{aerosol-source}} = \frac{(x/Ref^*)_{\text{aerosol}}}{(x/Ref)_{\text{source}}}$$

* - *Reference element Iron*

Enrichment Factors at Various Sampling Sites

| LOCATION | SITE -1 | SITE - 2 | SITE - 3 | SITE - 4 |
|-------------------|------------|-----------|-----------|-----------|
| NO. OF SAMPLES | 76 | 151 | 149 | 44 |
| ENRICHMENT FACTOR | 1.21 ± 0.6 | 1.3 ± 0.6 | 1.5 ± 0.7 | 1.1 ± 0.5 |

BERYLLIUM IN URINE (ng/ml)

| | OUR STUDY | LITERATURE VALUES |
|--------------|---------------|-----------------------------|
| CONTROL(10) | < 0.02 – 0.04 | 0.40 ±0.18, 0.24 ± 0.16 |
| EXPOSED (63) | 0.082 ± 0.07 | 0.13 ± 0.12, 0.24 ± 0.17 |

CONCLUSIONS

- **CONTROL MEASURES EFFECTIVE**
- **AIR CONCENTRATIONS (occupational & ambient) WELL BELOW THE LIMITING VALUES**
- **NO BERYLLIUM SENSITISATION OR CBD CASES DETECTED**
- **MORE EFFORTS FOR IMPROVING SAFETY IN BERYLLIUM HANDLING**
- **NEW PLANS FOR EXPOSURE CHARACTERISATION**
- **VERY LOW DISCHARGE OF BERYLLIUM IN EFFLUENT WATER**

FUTURE PLANS

- **Be AEROSOL MASS & NUMBER CONCENTRATION**
- **SPECIFIC SURFACE AREA MEASUREMENTS**
- **AEROSOL DISSOLUTION STUDIES IN SLF**
- **Be-LPT SCREENING**
- **MORPHOLOGY OF BERYLLIUM AEROSOLS**
- **ASSESSMENT OF CUMULATIVE EXPOSURE**
- **DERIVING EXPOSURE RESPONSE FUNCTION**
- **USE OF MORE ADVANCED SAMPLING TECHNIQUES FOR AIR MONITORING**

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Thank you

